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Reframing the Aid Effectiveness Debate

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Optimal Discipline in Donor-Recipient Relationships -Reframing the Aid Effectiveness Debate

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Abstract

Increased attention to the issue of aid effectiveness has sparked a flurry of empirical studies attempting to measure the macro-level impact of aid flows on the performances of developing countries. These studies yield ambiguous and even contradictory results and one possible source of confusion is the fact that they are not grounded in solid theorizing. This paper tries to remedy this lacuna by proposing a principal-agent model in which the donor monitors the use of aid and metes out sanctions in the event of fraud detection. Its most original feature lies in the assumed comparability between internal (domestic) and external (donor-imposed) disciplines and the resulting possibility of studying the behaviour of aggregate discipline. We show that, contrary to intuition, an (exogenous) improvement of domestic discipline may be over-compensated by the donor so that total discipline actually decreases and elite capture paradoxically increases. This implies that the relationship between domestic and total disciplines may be non-monotonous. We highlight the crucial role of the shape of the cost functions to obtain not only the above paradox but also corner solutions in which the donor optimally chooses to refrain from imposing any external discipline. The central lesson to draw from the whole exercise is therefore that no simple general testable prediction can be inferred from economic theory regarding the impact of aid on the donors' objective even when the quality of domestic governance or the policy environment is considered.

JEL Codes: D02, D86, O12, F35

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1 Introduction

Increased attention to the issue of aid effectiveness has sparked a flurry of empirical studies attempting to measure the macro-level impact of aid flows on the performances of developing countries. Following the seminal paper by Burnside and Dollar (2000), a standard approach consists of looking at the effect of aid on long-run growth rates controlling for quality of governance or the policy environment in recipient countries, itself interacted with aid. Their main result, namely that aid is effective when combined with good policies while “in the presence of poor policies, aid has no positive effect on growth” (p. 847), has been thoroughly challenged for its lack of robustness, and the available literature is replete with ambiguous conclusions and contradictory evidence, leaving a strong impression of disarray. Especially noticeable is the work of Rajan and Subramanian (2007, 2008) who found that the impact of foreign aid on growth is non-existent whatever is the estimation approach used, the type of aid or the time period considered. They attribute this disappointing result to the detrimental effect of aid on governance quality, in a way reminiscent of Easterly (2007) who drew attention to the critical role of incentives and the policy environment. In contrast, Arndt, Jones and Tarp (2010) have argued that, by applying a different econometric methodology to the data, a different conclusion can be reached, namely that aid has a positive and significant causal effect on growth over the long run. Other studies actually add fuel to this unsettled controversy (see, e.g., Dalgaard et al., 2004; Roodman, 2007; Djankov et al., 2008; Doucouliagos. and Paldam, 2009; Juselius et al., 2013), or show that uncertainty of aid impact also obtains when performance is measured by poverty reduction or inequality rather than economic growth (Masud and Yontcheva, 2005; Chong et al., 2009).

A central problem with this voluminous literature is that the main hypothesis put to the test is grounded in an intuitive argument whose logic appears quite straightforward. In this paper, we nevertheless argue that, as soon as we assume that domestic governance can be influenced by the donors, this simple logic can be deceptive. Since the idea of endogenous governance makes sense in the light of past and recent experiences in development aid strategies, solid theorizing is thus absolutely required to design valid and interpretable empirical tests.

Our analytical endeavor starts from the premise that donors resort to monitoring and sanctioning mechanisms in order to improve preference alignment, particularly with respect to poverty reduction. It is true that, in the scant theoretical literature devoted to the problem of aid effectiveness, several attempts feature a donor able to impose punishment on non-compliant recipient governments, typically through a conditionality mechanism (Azam and Laffont, 2003; Svensson, 2000, 2003; Gaspard and Platteau, 2012; Chauvet et al., 2012). The originality of our paper lies in the fact that the discipline brought to bear by the donor is made analytically comparable to the domestic discipline to which the target population subjects its own elite or government. In other words, governance of aid-funded programs can be conceived as the outcome of two types of discipline, internal and external, which can be somehow aggregated. As a

consequence, we are in a position to explore a new set of issues, such as whether internal and external disciplines are substitutes or complements, and whether an increase in internal discipline has the effect of also raising the level of total discipline and, therefore, the quality of governance.

Rather unexpectedly, there is no easy answer to the second question. Even though external and internal disciplines are substitutes, the donor *may* be induced to over-compensate a change in internal discipline in the recipient country. In particular, an increase in internal discipline may lead, paradoxically, to a fall in total discipline with the effect that the quality of governance, measured as the inverse of elite capture, actually decreases. Whether this happens or not depends not only on the initial level of internal governance, but also on the shapes of the cost functions and on the efficacy of monitoring by the donor. It also critically depends on whether the participation constraint of the local elite or government is binding or not. When it is binding, total discipline remains constant. Finally, a detailed analysis of the role of the cost functions shows how some particular shapes may lead to degenerate solutions in which external discipline is set to zero.

The implication of our analysis for empirical testing is therefore rather counter-intuitive : when aid effectiveness is measured by the proportion of aid that effectively reaches the targeted beneficiaries (or the inverse of local elite capture), countries with better initial levels of governance quality may well be less aid-effective than other recipient countries because the donor may choose to respond to better domestic governance by relaxing his own external discipline in a disproportionate way. If the required conditions are satisfied, we should not expect to find in the data the sort of positive relationship between aid, governance and performance that is typically presumed in the vast empirical literature devoted to the subject.

There are also practical policy implications, in particular the desirability to innovate in matters of supervision and punishment technologies so as to avoid situations in which the donor chooses to optimally abstain from exerting external discipline or to over-compensate improvements in local governance in the manner just described.

The paper proceeds as follows. In Section 2, we provide a snapshot of the history of successive approaches to development aid in the world donor community. This is with a view to showing the renewed importance of the aid effectiveness debate as well as the salience of the idea of external discipline. In Section 3, we then move to precise the setup of the model and place it in the context of the existing literature. In Section 4, its building blocks are presented, starting with the problem of the local government or elite (called the leader), and ending with the donor's problem after discussing the monitoring function. In Section 5, we analyze the general case that obtains when the participation constraint of the leader is not binding, leaving to Section 6 the more particular (and much more simple) case where this constraint is binding. In Section 7, a series of remarks or extensions are discussed and, in particular, we explain more carefully why our approach to modeling, focused on the interaction between internal and external disciplines, prevents us from describing the donor's

objective by the conventional altruistic function, such as is done in Azam and Laffont (2003), for example. Section 8 concludes.

2 Renewed interest for external discipline

Following disillusionment with past approaches to development aid that relied on conditionality programs and project aid, new principles have been formulated in the Paris Declaration (March 2005) and the Accra Agenda for Action (September 2008), itself followed by the Busan Partnership for Effective Development Cooperation (December 2011). The underlying idea is that aid effectiveness can be significantly raised through new aid modalities that emphasize ownership (giving more policy space to recipient governments) and 'policy dialogue', as well as transparency and accountability, reduce the role of conditionalities, and avoid reform overload. Following up on these principles, priority has been increasingly given to so-called General Budget Support (GBS) deemed to more effectively reduce poverty through non-earmarking of the aid funds and enhanced recipient country ownership.

After a few years of active implementation of the new strategy, however, donor agencies came to realize that excessive hopes had been placed in it, especially when there is a wide divergence between their objectives and those of the recipient countries. In practice, indeed, the donors started budget support even when entry conditions were not met and the recipient governments just committed to or stated their intentions of improving policies, governance or public financial management. In other words, donors used GBS to bring about the desired changes in policies and governance instead of supporting deserving governments (Dijkstra, 2013). A major conflict thus emerged between the objective of reducing transaction costs and engaging recipient governments by providing freely spendable money that can be used in line their own priorities, on the one hand, and the objective of influencing their policies and governance in a way considered appropriate by the donor agencies, on the other hand. The latter typically included such concerns as organizing free and fair elections, establishing the rule of the law and an independent judiciary, fighting against corruption, enacting sound macroeconomic policies, and committing to poverty reduction.

The reaction of many donor agencies to this predicament consisted of reintroducing substantial ex post conditionalities, often via the threat of withholding further tranches of aid money in case of the recipient's non-compliance with the donor's conditions. This implied that GBS can be suspended or reduced, such as happened with Nicaragua, for example, when the European Union and bilateral donors concluded that the government of prime minister Ortega did not want to fulfill his commitment to ensure free and fair elections in the country (Dijkstra, 2013). The World Bank, to give another example, decided to halt its budget support to the government of Honduras and to replace it with project funding after the International Monetary Fund did not renew a standby agreement (2013). More significantly, several aid agencies known for their rigorous

approach to aid cooperation (such as SIDA in Sweden, or DFID in the United Kingdom) have begun to retreat from GBS programmes altogether, owing to serious misuses of aid resources (see the evaluation reports by SADEV, 2010, and DFID, 2011). Thus, in a review the OCDE notes that “weak systems to align with and a high risk of corruption have influenced Swedish readiness to provide general budget support” (OECD DAC, 2009, p. 47). In this context, it is not surprising that in the corridors of aid agencies a “Paris Agenda fatigue” is increasingly mentioned (Oden and Wohlgemuth, 2011). Also in line with the above diagnosis, the European Union has re-introduced the concept of result-based disbursements into its budget support programmes (part of the aid is variable, being released in successive tranches conditioned on the performances of the country),¹ and the World Bank is launching a new results-based lending instrument, the so-called Program-for-Results.

None the less, it is easy to understand why, among different aid modalities, budget support is most difficult to fit into a donors’ imposed disciplining mechanism, as the aforementioned experiences of Nicaragua and Honduras attest. GBS is bound to be linked to the fulfillment of fundamental principles that are politically sensitive, arguable, and difficult to implement in a rather short time (on the latter point, see Pritchett et al., 2013). At the other extreme, project aid is probably the easiest to bring into the purview of external discipline (although the resulting transaction costs are likely to be larger), and programme aid occupies the middle ground (see Bigsten, 2013).

A detailed empirical study based on a review of 1426 World Bank projects completed between 1981 and 1991 highlights the potential contribution of monitoring to effectiveness of project aid (Kilby, 1995).² This study indeed concludes that (i) past supervision has a positive and perceptible impact on project performance; (ii) early supervision is much more effective than later supervision; and (iii) the impact of supervision is relatively homogenous across regions, sectors and macroeconomic conditions. Moreover, the benefits of supervision greatly exceed the costs: a substantial and sustained increase in the average level of supervision may generate a noticeable improvement in the average economic rate of return. Using the same dataset, Chauvet et al. (2012) argue that not only a more precise supervision of projects increases the likelihood of project success, but the effect of higher monitoring precision is significantly more effective when interests between donor and recipient (as perceived by the donor) are more diverging.

¹Through the so-called split response mechanism, the donors link disbursements of a portion of aid money to a general assessment of the principles agreed upon with the recipient government, and the other part to the degree of performance of specific indicators specified in the Performance Assessment Matrix (Dijkstra, 2013: 116).

²Endogeneity (supervision influences performance which in turn influences subsequent supervision allocation decisions) is overcome by relating lagged annual supervision to annual changes in interim performance.

3 The setup of the model

In writing the model, we stick to a well-established tradition whereby the incentive aspects of alignment between the interests of donors and recipient governments are analyzed within the principal-agent framework. We restrict our attention to the one-donor-one-recipient case because the issue that we want to address, the interaction between internal and external disciplines, is in itself quite complex. The ultimate purpose of such an attempt is admittedly to revisit the problem of aid allocation between several recipient countries in the presence of an explicit tradeoff between considerations of needs and governance (the most needy countries are not necessarily excluded from aid programmes because their domestic governance can be improved by the donor community). However, owing to the ambitious character of the whole project, we decided to leave the second step of the analysis to another paper (Bourguignon and Platteau, 2013).

Given the perspective that we adopt, a central question is how to represent governance. We measure governance by an outcome variable, namely the inverse of elite capture or the share of aid flows that reaches the ordinary citizens or the poor. When this share is larger, governance is considered to have improved. A disciplining mechanism is considered to be operating when not only the elite's utility from fraud decreases as the imposed discipline gets tighter, but also the marginal loss of utility caused by such a tightening increases when fraud or embezzlement is larger. The elite is disciplined internally when the local society exerts its own control, or externally when the discipline is imposed by the donor. Discipline is internally activated if the national community punishes fraudulent behavior in some way or other. The punishment meted out by the local society can be conceptualized as a 'tax' imposed on the share unduly appropriated by its elite. Alternatively, such a 'tax' can be regarded as being self-imposed in the sense that the elite may feel some guilt vis-à-vis its own people when appropriating part of the aid flow. Whereas internal discipline is assumed to be exogenous, external discipline is optimally chosen by the donor when it decides the level of its monitoring activity and the amount of punishment imposed in the event of fraud detection.

As a matter of fact, unlike the community which is assumed to perfectly observe the fraud, the donor agency may get unequivocal evidence of it only with a positive probability. This is, of course, a simplified framework which we adopt only for the sake of capturing the fact that citizens - and a fortiori the leader itself if the internal discipline is self-imposed - are better informed than outside agencies about the behaviour of their elite or authorities. On the other hand, since direct punishment may prove practically difficult to enforce for an external organization, it helps to think of sanctioning as the withdrawal of future benefits (the leader, for example, would be put on a black list that would prevent him from receiving aid funds any time in the future).

Finally, the probability of fraud detection depends positively on the precision of monitoring (which is costly), and on the extent of the embezzlement by the leader. Monitoring expenditures are incurred ex ante in contrast to punishment costs, which are only incurred when fraud is actually detected. The

recipient decides how much aid money it appropriates, knowing the level of internal discipline and the monitoring precision and punishment decided by the donor.

Our model bears some similarities with the model of Chauvet et al. (2012) where the donor also chooses the levels of monitoring precision and punishment (amount of the second tranche of aid money, which is conditionally disbursed) with the aim of disciplining the recipient. The level of internal discipline, conceived as the extent of congruence of interests between the donor and the recipient, is exogenously given. The recipient chooses the level of effort which influences the probability of detection of inappropriate behaviour by the donor. Likewise, in Gaspart and Platteau (2013), the donor again chooses the amount of monitoring (expenditures) and the level of punishment (also measured by the amount of a second tranche). Yet, in their model, internal disciplining of the local elite is achieved by the exit options of a bargaining game between this elite and the grassroots. The donor chooses the level of embezzlement which influences the probability of detection.

In neither of these two aforementioned models, however, can we directly compare internal and external disciplines. As a consequence, effects on total discipline, conceived as the sum of the internal and external components, cannot be studied. The same holds true of Svensson (2000), where the recipient country is disciplined because the aid contract specifies the amount of aid disbursed as a function of observed performances that confound the effects of a shock and of internal reform effort. It is also true for Azam and Laffont (2003) who look for the optimal aid contract. According to this contract, the recipient government will receive an aid amount (which is endogenous) linearly dependent on the level of consumption of the poor that it provides. Such a rule is considered by the authors as describing the conditionality mechanism in a stylized manner.

Before turning to the task of presenting the building blocks of our model in formal terms, it is worth noticing that, because the setup of our theory involves monitoring and punishment mechanisms, it has links both to general contract theory and to the law and economics literature. Regarding the latter, we have more specifically in mind the strand of literature dealing with crime and punishment (see, e.g., Garoupa, 1997), whereas for the former we think of (i) contracts in which a minimum level of performance is set by the principal, and contract is not renewed if violation of this condition is detected. (see, e.g., Otsuka, Chuma, and Hayami, 1993; Bolton and Dewatripont, 2005)³, and of (ii) contracts in which a bonus is offered to the agent if performance (e.g., the quality of a good sold) has been verified to be of acceptable quality and a penalty is imposed if it is not (MacLeod, 2007). In the case of contracts of type (ii), penalties may consist of loss of reputation, loss of future access to the market, harassment, threats and court action (Fafchamps, 2004). As is evident from the above description, our setup implies a contract (ii) but of the asymmetric kind (no bonus is provided).

³Violation is detected with a positive probability that depends positively on the degree of shirking and resources devoted to supervision

4 The building blocks

Our model is deliberately parsimonious because the issue that we tackle is complex, and we need to achieve interpretable results that can be relevant for donor agencies and policy-makers. In this section, we successively describe the objective function of the leader or the elite, the probability function for fraud detection, the leader's optimal behavior given the aid delivery parameters chosen by the donor, and the latter's maximization problem yielding the optimal values of these parameters. Note that a complete list of the notations used is presented in Appendix A.

4.1 Objective of the leader

For each unit of aid, the leader's problem is written:

$$\underset{y}{Max} V(y) = y - \gamma\pi(by) - \beta y^2 - g \quad (1)$$

Bearing in mind that y is the share of aid appropriated by the leader or the elite of the recipient country (that is, the extent of 'fraud'), so that $y \in [0, 1]$, the first two terms show the expected gain by the leader, assuming he/she will have to pay the whole penalty, γ , which the donor inflicts if a fraud is detected. The probability function, $\pi(y)$, is the probability of the fraud being detected at the monitoring precision, $b = 1$. By increasing the monitoring precision, b , the donor may therefore increase the probability of fraud detection, $\pi(by)$, for any given y . The third term in the above expression is the cost of the fraud for the leader, with β representing the intrinsic, or domestic governance parameter of the recipient country ($\beta \in [0, 1]$). As we have pointed out earlier, the cost of fraud may be conceived as the cost imposed by the national community or as a self-inflicted cost, such as when the leader makes voluntary gifts to clients to buy their accomplicity. In keeping with our understanding of the disciplining mechanism, the relationship between this cost and the extent of the fraud, y , is assumed to be increasing and convex. In this way, we ensure that not only the leader's utility, V , decreases as β is raised, but also that the marginal loss of utility caused by an increase in β is greater when the fraud is more important, that is $V_{y\beta} = \frac{\delta^2 V}{\delta\beta\delta y} \leq 0$. As will become clear when the probability of fraud detection is specified, the same property applies to externally imposed discipline: in this case, it is the marginal loss of leader's utility caused by an increase in either b or γ that grows when the leader appropriates a larger share of the aid transfer.

The last component of the leader's utility function, g , is the cost of handling one unit of aid, which is assumed to be constant (it is, therefore, independent of the amount of the fraud). Such a cost includes all the expenses or effort that the leader must incur in order to get hold of the aid amount by applying to the donor agency, organizing meetings with the intended beneficiaries, receiving foreign experts, submitting follow-up reports, and the like. Note that $V(y) \in$

$[-g, 1 - \beta - g]^4$, from which it also follows that $g \leq 1$ - if the reservation utility of the leader is 0.⁵

The above leader's utility function is unconventional in the sense that it does not follow the literature on the subject (see Section 2). In this literature, the utility function chosen for the recipient government does not include an expected punishment component and is typically a simple altruistic function which is sometimes supposed to describe what Foster and Rosenzweig (2002) have called a "traditional aristocratic governance structure". The coefficient representing the leader's (government's) altruism can be interpreted as a governance parameter, since it reflects the weight given by the leader to the welfare of the community. The reason why we depart from this practice and the implications of doing so is discussed in section 6.

4.2 Specifying $\pi(y)$

The outcome of the aid program observed by the donor is :

$$x = (1 - y) + u$$

where u is a random measurement error with cdf $F_u()$. Knowing that function, the donor is able to infer the distribution of probability of y given the observed outcome x .

The donor infers the probability of fraud, say $y > Y$, where Y is an arbitrary threshold, from observing x knowing $F_u()$.

$$\Pr \{y > Y\} = \Pr \{(1 - x) + u > Y\} = 1 - F_u[Y - (1 - x)]$$

Punishing will occur if this probability is above some threshold $1 - \theta$, that is:

$$F[Y - (1 - x)] \leq \theta \iff x \leq 1 - Y + F_u^{-1}(\theta) = \xi \quad (2)$$

In other words, the donor senses fraud when the observed output is below some threshold, ξ , that depends on Y and θ .

Given such behavior by the donor, the probability $\pi(y)$ for the fraud to be detected as a function of the fraud y is given by :

$$\pi(y) = \Pr \{x = 1 - y + u \leq \xi\} = F_u[y - (1 - \xi)] \quad (3)$$

In what follows, we assume that $F_u()$ has the usual S-shape form over some support interval $[-d, +d]$, being convex in a first part of the interval and concave over the rest of the interval. As the probability function $\pi()$ is initially convex, it can be seen that the utility function of the leader in (1) is concave for low enough values of y .

⁴Indeed, the minimum value of $V(y)$ is $-g$ (when $y = 0$), and its maximum value is $1 - \beta - g$ (when $y = 1$, and the leader is lucky enough to have his or her fraud undetected).

⁵If β is close to zero, indeed, the maximum value of the leader's utility is $1 - g$. If this were negative, the leader would be better off refusing the aid money.

Non-degenerate solutions of the models to be analyzed always occur in the convex part of the fraud detection probability function. To simplify, we shall assume that this function is indeed quadratic : $\pi(y) = y^2/a^2$, where a may be interpreted as the natural variance of the outcome of the aid program. Of course, this is for y being in the interval $[0, a]$. A more rigorous specification actually would be:

$$\pi(y) = \text{Inf} (y^2/a^2, 1)$$

In what follows, only the 'interior' specification $\pi(y) = y^2/a^2$, where non-degenerate solutions are found, will be considered. The implications of considering the counter-intuitive corner solution $\pi(y) = 1$ are discussed in section 6.

Assume now that the donor is able to modify the distribution of the outcome random component, u , through monitoring. A convenient assumption is that the donor can scale the random component up or down by a factor $b \geq 0$. The cdf of the noise in the outcome observation, $v = u/b$, is now given by:

$$F_v(v) = F_u(v/b)$$

When the degree of monitoring precision is explicitly taken into account (instead of being implicitly set to the value one, as before), we obtain the following, more general form of the detection probability function:

$$\pi(by) = \frac{(by)^2}{a^2} \quad (4)$$

Finally, it makes sense to require that the probability of fraud detection be zero when there is no fraud. This implies that $F_u [-(1 - \xi)] = 0$, which permits identifying ξ once the original distribution of the noise, $F_u()$, is known. A more general specification where the leader can embezzle a proportion h of aid with no probability of being detected is discussed in section 6.

4.3 The leader's behaviour

The interior solution of the leader's program, (1), is given by $dV/dy = V_y = 1 - 2\beta y - b\gamma\pi'(by) = 0$. When $\pi = (by)^2/a^2$, this yields the optimal level of embezzlement, $\tilde{y}(b, \gamma)$:

$$\tilde{y}(b, \gamma) = \frac{1}{2(\beta + b^2\gamma/a^2)} \quad (5)$$

It will be convenient in what follows to define a measure of aggregate external discipline imposed by the donor:

$$\varphi = \frac{b^2\gamma}{a^2} \quad (6)$$

The optimal fraud can then be written simply as:

$$\tilde{y}(b, \gamma) = \frac{1}{2(\beta + \varphi)} \quad (7)$$

Note that, at this optimum and according to intuition, the marginal utility of fraud, V_y , is a decreasing function of both the internal and the external discipline. It follows that the share embezzled by the leader decreases when either internal governance, β , improves or the donor tightens his disciplining instruments (the monitoring precision and/or the amount of the punishment). It also increases with the noise, a , in the measurement of the aid outcome, since this diminishes the probability that the fraud will be detected.

In the above argument, we have assumed that the behavior of the leader was such that the quadratic probability of detection of the fraud is below unity. The issue of a degenerate corner solution at $\pi(by) = 1$ is discussed in section 6.

Note that the corner solution $y = 1$ has been ignored in this description of the solution. One way of ruling it out is to assume that $\beta \geq 1/2$, which we will do. In other words, we assume that, even without external disciplining, the leader never steals the whole aid fund. On the other hand, the leader will never choose to refrain from cheating altogether because dV/dy is necessarily positive when $y = 0$.

4.4 Optimal punishment/monitoring by the donor

Let $C(b)$ be the cost of monitoring the use of aid, $C()$ being increasing and convex. $C(b)$ is thus the cost incurred by the donor per unit of aid to achieve a certain level of precision in detecting fraud. The higher the precision b desired by the donor the higher the cost to be incurred and also the higher the marginal cost of enhancing precision. Likewise, $D(\gamma)$, with $D()$ increasing and convex, is the cost per unit of aid for the donor of imposing a level of punishment γ on the leader. $D(\gamma)$ may include the cost involved in the participation in an information-sharing network designed to ensure publicity about fraudulent acts committed by unscrupulous leaders or the harsh image that too severe a donor would give to its constituency or development NGOs. Whereas the monitoring cost, $C(b)$, is incurred ex ante, since it is aimed at detecting fraudulent behavior, the cost of punishment for the donor, $D(\gamma)$, is incurred ex post, that is, only after the actual detection of a fraud which occurs with probability $\pi()$.

The objective of the donor is assumed to depend logarithmically on people's welfare in the recipient country and on the cost of disciplining the leader. It is therefore written as:

$$\text{Max}_{\gamma, b} \text{Log}[w + T(1 - \tilde{y}(\gamma, b))] - C(b)T - \pi(b\tilde{y}(\gamma, b))D(\gamma)T \quad (8)$$

where w is the per capita income of the community without aid and T the total amount of aid per capita, which is taken as exogenous.

The specification (8) is voluntarily simplified. Calling Γ the total cost of managing aid, that is disciplining the leader, a more general specification of the

donor's objective would be:

$$\text{Max } W [w + T(1 - \tilde{y}(\gamma, b)), T + \Gamma] \quad (9)$$

with this function being increasing and concave with respect to its first argument and decreasing and convex with respect to its second argument, i. e. the total cost of aid. In this specification both the amount transferred and its cost would be endogenous. The specification (8) may be considered as a special case of (9), where W is assumed to be additive and linear with respect to its second argument. Also, the maximization may be assumed to be sequential, only the first step where the net transfer T is taken to be exogenous being considered in this paper. In Section 6, some clues will be provided on the implications of considering this more general specification.

Maximization as described by (8) must take place under the participation constraint of the leader. Assuming that the leader's utility function is linearly homogeneous in T (it is equal to the utility derived from one aid unit times the number of aid units available), and that the cost of handling T units of aid is T times the unit cost ($= gT$), we may continue to express the participation constraint as before:

$$\tilde{y}(\gamma, b) - \beta \tilde{y}^2(\gamma, b) - \gamma \pi [b\tilde{y}(\gamma, b)] - g \geq V^0 \quad (10)$$

where V^0 is the reservation utility of the leader per unit of aid which will be assumed to be 0, except otherwise specified. In other words, the donor must make sure that the leader can at least cover the cost of handling aid. Using the expression of the indirect utility V^* above, and considering an interior solution (regime 1), the participation constraint writes simply:

$$1/(4(\beta + \varphi)) - g \geq 0 \quad (11)$$

As far as the participation constraint of the donor is concerned, we will assume that the parameters of the model are such that, at equilibrium:

$$\text{Log} [w + T(1 - \tilde{y}(\gamma, b))] - C(b)T - \pi(b\tilde{y})D(\gamma)T > \text{Log}(w) \quad (12)$$

In other words, we assume that the income per head in the recipient country is sufficiently low and/or the parameters of the cost functions are sufficiently small to make the donor's participation constraint automatically satisfied.

Now, the Lagrangian of the donor's maximization problem can be written:

$$\begin{aligned} \Lambda = & \text{Log} [w + T(1 - \tilde{y}(\gamma, b))] - C(b)T - \pi(b\tilde{y})D(\gamma)T \\ & + \mu \{ \tilde{y}(\gamma, b) - \beta \tilde{y}^2(\gamma, b) - \gamma \pi [b\tilde{y}(\gamma, b)] - g \} \end{aligned} \quad (13)$$

where μ is the Lagrangian multiplier associated with the leader's participation constraint. Two situations can then arise depending upon whether this constraint is binding at equilibrium or not. The case where it is binding reflects conditions under which the monitoring and punishment technology is cheap

enough to allow the donor to prevent the leader from obtaining any surplus. Conversely, when the cost of this technology is too high, the donor will not find it profitable to put the leader at his reservation utility. In the exposition that follows, we start by examining the latter, more general case, which also turns out to be the more analytically complex.

5 The general case: the leader's participation constraint is not binding

As the leader's participation constraint is not binding at equilibrium, the Lagrangean coefficient μ is nil in (13). By replacing the probability π by its value in terms of the donor's instruments, the donor's problem can be rewritten as follows:

$$Max_{b,\varphi} W = Log \left[w + T \left(1 - \frac{1}{2(\beta + \varphi)} \right) \right] - TC(b) - TD(\gamma) \left[\frac{1}{4} \frac{b^2}{a^2} \frac{1}{(\beta + \varphi)^2} \right] \quad (14)$$

$$with \quad \varphi = \frac{b^2 \gamma}{a^2}$$

To simplify the analysis in this section, we set $a = 1$ and we specify the two cost functions as convex power functions:

$$C(b) = \frac{cb^q}{q}, \quad D(\gamma) = \frac{d\gamma^m}{m}, \quad with \quad q \geq 1, \quad m \geq 1$$

Then, using the definition of φ above to express γ as a function of b and φ , the donor's problem becomes:

$$Max_{b,\varphi} W = Log \left[w + T \left(1 - \frac{1}{2(\beta + \varphi)} \right) \right] - Tc \frac{b^q}{q} - \frac{Td}{4m} \frac{b^2}{(\beta + \varphi)^2} \frac{\varphi^m}{b^{2m}} \quad (15)$$

Proceeding sequentially, we first optimize this function with respect to b for given φ . This yields the total cost $\Gamma(\varphi)$ of implementing the external discipline at the level φ .

$$\Gamma(\varphi) = Min_b Tc \frac{b^q}{q} + \frac{Td}{4m} \frac{b^{2(1-m)}}{(\beta + \varphi)^2} \varphi^m \quad for \quad given \quad \varphi \quad (16)$$

the solution of which is given by:

$$b^*(\varphi) = \left[\frac{d}{c} \frac{m-1}{2m} \frac{\varphi^m}{(\beta + \varphi)^2} \right]^{\frac{1}{q+2(m-1)}} \quad (17)$$

and, after plugging this expression back into (16), we obtain the following expression for the cost of the external discipline:

$$\Gamma(\varphi) = B \left[\frac{\varphi^m}{(\beta + \varphi)^2} \right]^p \quad (18)$$

where:

$$B = \frac{Tc^{1-p}d^p2^{-p-1}}{q(m-1)^{1-p}m^p}[(m-1)2+q]; \quad p = \frac{q}{q+2(m-1)} \quad (19)$$

For future use, the corresponding marginal cost can be expressed as:

$$\Gamma'(\varphi) = \frac{\eta}{\varphi} \Gamma(\varphi); \text{ with } \eta = p \left[m - \frac{2\varphi}{\beta + \varphi} \right] \quad (20)$$

where η is the elasticity of the cost with respect to external discipline, φ .

The original maximization problem (15) writes now:

$$\underset{\varphi}{Max} W = Log \left[w + T \left(1 - \frac{1}{2(\beta + \varphi)} \right) \right] - \Gamma(\varphi) = U(\varphi) - \Gamma(\varphi) \quad (21)$$

where $U(\varphi)$ can be interpreted as the donor's utility of disciplining the leader. An interior solution, if it exists, is then obtained by equalizing the corresponding marginal utility of the external discipline, and the marginal cost, $\Gamma'(\varphi)$. But a corner solution at $\varphi=0$ cannot be excluded.

It turns out that the type and properties of the optimal external discipline strongly depend on the curvature of the cost functions or on the parameters m and q . Four cases have to be distinguished depending on whether the convexity of the cost functions, $C(b)$ and $D(\gamma)$, is more or less pronounced than that of the quadratic function that describes the probability of detection, $\pi()$ - i.e; whether m or q are greater or smaller than 2 - and whether the solution is interior or at the 0 corner.

5.1 Case $m < 2$.

It can be seen from (18) and (19) that $m < 2$ implies that the cost of the external discipline tends towards zero when its level becomes infinitely large, whereas the utility $U(\varphi)$ is also maximal. It follows that the optimal value of the external discipline is infinite. This is easy to interpret. The condition $m < 2$ implies that, as the level of external discipline is raised, the cost of punishment for the donor increases less quickly than the probability of actually incurring that cost (i.e. the probability of detection) decreases. Thus, the expected cost of punishment tends towards zero when the punishment becomes infinitely large. This case of extreme severity in which the leader is actually deterred from embezzling aid money is analogous to the result of extreme penalty in the theory of optimal crime prevention - see, for instance, Garoupa (1997).

Yet, in the present case where the leader has the possibility to opt out of the aid program, this case is irrelevant. Clearly, the participation constraint of the leader cannot be satisfied when he/she gets no benefit from aid - $\tilde{y} = 0$ as $\varphi \rightarrow \infty$ from (7)-, but must pay a cost, g . If the donor insists in giving aid to the recipient

country, then it must set the external discipline at the level consistent with the leader's participation constraint, which is the case studied in the next section.

5.2 Case $m \geq 2$, $q > 2$.

We now come back to the more realistic case where $m \geq 2$ and write the first-order condition of the donor's optimization problem. Differentiating the first term in (21) yields the marginal utility:

$$U'(\varphi) = \frac{(\beta + \varphi)^{-2}}{w + T(1 - \frac{1}{2(\beta + \varphi)})} \quad (22)$$

which is monotonically decreasing with respect to φ and, as could be expected, tends towards zero when φ tends towards infinity - see Figures 1 to 4.

If strictly positive, the optimal level of the external discipline, φ , is then given by equalizing the marginal cost defined above with the marginal utility:

$$U'(\varphi) = \Gamma'(\varphi) \quad (23)$$

It turns out that the analysis of that first-order optimality condition is rather intricate. Knowing the shape of the marginal utility function, a simpler way to proceed consists of considering the relative value $R(\varphi) = \Gamma'(\varphi)/U'(\varphi)$ of the marginal cost with respect to the marginal utility rather than both of them separately. An interior solution is then given by equalizing this ratio to unity. From the set of equations (18), (19) and (20), and from equation (22), it comes after rearranging that:

$$R(\varphi) = Bp[(m-2)\varphi + m\beta] \left[\frac{\varphi^{mp-1}}{(\beta + \varphi)^{2p-1}} \right] \left[w + T(1 - \frac{1}{2(\beta + \varphi)}) \right] \quad (24)$$

If $q > 2$ and $m \geq 2$, as assumed in this subsection, it can be shown that the three terms in square brackets are increasing functions of φ and $R(\varphi)$ increases monotonically from zero to infinity when φ goes from zero to infinity - see Appendix B. It follows that $R(\varphi)$ necessarily goes through unity. For the corresponding value of φ , the marginal cost is equal to the marginal utility. Thus, there is a single intersection point between the marginal cost and the marginal utility curve, and therefore, a single (interior) solution to the optimality condition (23). Moreover, the marginal cost curve crosses the marginal utility curve from below so that the second order condition for optimality is satisfied, whatever the actual shape of the marginal cost curve - see Figure 1.

We now look at the comparative statics of this interior solution with respect to the internal discipline β . Several interesting results emerge. Combined with the existence result, the first one may be stated as follows :

Theorem 1. (*Existence and substitutability*) *If $q > 2$ and $m \geq 2$, the optimal external discipline is strictly positive and is a substitute to the internal discipline: an increase in internal discipline, β , diminishes the optimal external discipline, φ .*

At first sight, this property seems very intuitive. With a better internal discipline, the leader allocates a larger share of aid to the grassroots population in the recipient country, and this reduces the marginal utility of the external discipline for the donor. Without major change in the marginal cost, the external discipline should diminish. What is less evident, however, is the way the marginal cost is modified. It can be seen from (20) that an increase in β has two opposite effects on the marginal cost. On the one hand, it increases the elasticity, η , of the cost with respect to the level of external discipline but, on the other hand, it reduces the ratio $\Gamma(\varphi)/\varphi$ (bearing in mind that $mp - 1 = \frac{(m-1)(q-2)}{q+2(m-1)}$, which is always positive under the assumed conditions). Of course, the substitutability between internal and external disciplines is reinforced if the marginal cost increases, that is, if the former effect is stronger than the latter. In the opposite case where the marginal cost decreases with β , it is shown in Appendix B that it decreases less than the marginal utility, so that the substitutability between internal and external disciplines holds in that case too.

The question now arises of the extent of the substitution of internal by external discipline. Is it only partial, or could it possibly overshoot the initial change in internal discipline? The substitution is partial (under-substitution) if the total discipline $\beta + \varphi$ increases when β increases, or:

$$-1 \leq \frac{d\varphi}{d\beta} \leq 0 \quad (25)$$

Alternatively, over-substitution occurs when :

$$\frac{d\varphi}{d\beta} \leq -1 \quad (26)$$

In this second case, therefore, overall discipline falls despite the fact that its internal component, β , has increased.

A rather simple condition determines whether over- or under-substitution occurs (see Appendix B):

Theorem 2. *(under- and over-compensation) An increase in internal discipline, β , is always compensated by a drop in external discipline, φ . There is under-compensation, i.e. total discipline, $\beta + \varphi$, increases, iff:*

$$\eta > 1 \quad (27)$$

There is over-compensation, i.e. total discipline, $\beta + \varphi$, decreases, otherwise. In this second eventuality, the optimal level of fraud increases despite the higher level of internal discipline.

A formal proof of the above theorem is given in Appendix B. An intuitive proof is as follows. Consider the equilibrium condition (23) and a small simultaneous change in internal and external discipline leaving the total discipline unchanged: $\Delta\beta + \Delta\varphi = 0$ or $\Delta\varphi = -\Delta\beta$. Clearly, the marginal utility is unchanged. This is not true of the marginal cost, though. Since η is the elasticity

of the total cost, the marginal cost may be approximated by $\Gamma' = \eta\varphi^{\eta-1}$, and the change in the marginal cost by $\Delta\Gamma' = -\eta(\eta-1)\varphi^{\eta-2}\Delta\beta$. If $\eta = 1$, equilibrium has not been disrupted and there is no need for a further change in φ . There is perfect substitution between internal and external discipline. If $\eta > 1$, the marginal cost has moved down and it is thus necessary to increase φ (that is, φ falls to a smaller extent than what is needed to keep $\beta + \varphi$ constant) in order to get back to equilibrium. There is under-compensation: total discipline therefore goes up together with internal discipline, yet it increases to a smaller extent. Finally, the marginal cost moves up if $\eta < 1$, which requires a drop in φ beyond what allows to keep $\beta + \varphi$ constant if equilibrium is to be re-established. There is then overcompensation and the total discipline falls despite the fact that the internal discipline has improved.

The intuition of this apparently paradoxical result is simple. When internal discipline increases, the fraud committed by the leader decreases, and the grassroots receive more aid so that the marginal utility of the donor falls. To re-establish equilibrium, the donor must reduce its marginal cost, which he does by lowering φ . By how much depends on the elasticity of the marginal cost, which depends itself on the convexity of the cost function, which is related to its elasticity. If it is large, the change in φ needed to reequilibrate the optimality condition is small and the change in the overall discipline remains positive. If the elasticity of the cost function is small, however, re-establishing optimality requires a large change in φ , which may lead to the a decline in the overall discipline. Note, however, that things are slightly more complicated since the elasticity of the cost function actually depends itself on both the internal and external disciplines. Thus, condition (27) is a condition on the whole set of parameters of the model.

An important consequence of Theorem 2 is the following :

Theorem 3. *(non-monotonicity) The relationship between internal discipline (β) and total discipline ($\beta + \varphi$) or the level of the fraud $(1/2)(\beta + \varphi)^{-1}$ is not necessarily monotonous. If $m \geq 2$ and $q > 2$ and if initially there is over-substitution of internal by external discipline and the optimized fraud is an increasing function of β , both properties are likely to revert at some stage as β increases.*

The proof - see Appendix B - directly follows from Theorems 1 and 2 and from the definition of η as given by (20). Notice first that the elasticity η is a decreasing function of $(\varphi/\beta + \varphi)$. Second, it is evident that $(\varphi/\beta + \varphi)$ is a decreasing function of β since $d\varphi/d\beta < 0$ on the basis of Theorem 1. It follows that $d\eta/d\beta > 0$. As β increases, η moves from smaller to larger values so that under-compensation follows over-compensation when internal discipline in the recipient country improves. The turning point is given by:

$$\eta = 1 \text{ or } \frac{\varphi}{\beta + \varphi} = \frac{(m-1)(q-2)}{2q}$$

Clearly, the more convex are the cost curves (the larger the values of m

and/or q), the less likely over-compensation will occur, which is according to the intuitive explanation of Theorem 2 above.

Considering now the comparative statics with respect to the other parameters of the model, the following results are easily obtained:

Theorem 4. *(other comparative statics) The external discipline is a decreasing function of the monitoring and punishment cost parameters, c and d , and of the income of the recipient country. The external discipline is also decreasing with the size of the transfer.*

The proof is immediate from differencing (23) with respect to B and φ . That higher values of the cost parameters reduce the extent of the external discipline is rather obvious. What is perhaps less evident is that the initial income of the population in the recipient country has the same effect. This is easily understood, though. Other things being equal, it can be seen on (22) that an increase in the income of the population, w , causes the marginal utility of the donor to fall. Equilibrium is re-established by reducing the discipline so as to lower the marginal cost. Put in the converse manner, the optimal external discipline is more severe for poorest countries with the same level of intrinsic governance, the size of the transfer being the same.

Regarding the effect of a change in the amount of aid transferred, the proof is again straightforward. Bearing in mind the definition of B given in (19), it is obvious from (23) that the marginal cost of external discipline, Γ' , increases with T (the increase is strictly proportional). As for the the marginal utility, (22) implies that it unambiguously decreases as T rises. Clearly, optimality is re-established by reducing external discipline.

Getting now into the detail of the external disciplining policy, the following result holds (see Appendix B for the proof):

Corollary 1. *The optimal levels of monitoring and punishment both decrease monotonically with the level of internal discipline.*

Finally, one may wonder how the individual disciplining instruments react to the cost parameters, c and d . The following results are easily established and fit common sense.

Corollary 2. *The monitoring and the punishment are decreasing functions of their own cost. However, whether they are gross complements or substitutes is ambiguous.*

Take the case of the optimal monitoring, given by (17). An increase in c clearly reduces the extent of monitoring for given external discipline, φ . As the external discipline falls with the two cost parameters, and as $\varphi^m/(\beta + \varphi)^2$ varies in the same direction as φ (since it is assumed that $m \geq 2$), the overall effect of a change in c on b^* is negative. The corresponding two effects when the cost of punishment increases are opposite to each other. Hence the ambiguity.

5.3 Case $m \geq 2$ and $q \leq 2$

Let us consider first the case where q is strictly less than 2. In that case, it can be seen from (18) and (20) that the marginal cost becomes increasingly large when φ becomes infinitely small (since $mp - 1 < 0$ when $q < 2$). The ratio function $R(\varphi)$ is thus U-shaped going from infinity when $\varphi = 0$ to infinity when $\varphi = \infty$. In between, it is shown in Appendix B that $R(\varphi)$ goes through a minimum for some value φ_m . Two cases can therefore arise. Either this minimum is above unity, $R(\varphi_m) > 1$, in which case the optimal discipline is the 'corner solution' $\varphi = 0$ since the marginal cost is then everywhere above the marginal utility - see Figure 2. Or the minimum is below unity, in which case the marginal cost curve crosses the marginal utility curve twice. However, only the second intersection point, φ^I , satisfies the second-order optimality condition - see Figure 3. It is shown in Appendix B that the optimum is of the type described by φ^I , if the internal discipline parameter, β , is sufficiently low, or if the cost parameters, c and d , and/or utility parameters w and T are sufficiently small. It is $\varphi = 0$ if they are not. In other words, the optimal discipline is zero if the internal governance is good enough, or if the cost of the aid delivery and/or the income level in the income recipient country and the size of the transfer are high enough.

The following theorem follows from these properties.

Theorem 5. (*Corner solution*) *If $m > 2$ and $q < 2$ then there exist values $\bar{\beta}$ ($\geq 1/2$) and $\bar{\varphi}$ (> 0) of the internal and external discipline such that the optimal discipline, φ^* , satisfies:*

$$\varphi^* = 0 \text{ if } \beta \geq \bar{\beta} \text{ and } \varphi^* \geq \bar{\varphi} \text{ if } \beta < \bar{\beta}$$

The set of values of the model parameters (c, d, w, T) for which $\bar{\beta}$ is strictly above its minimum $1/2$ is non-empty.

The proof of this theorem is given in Appendix B. The key property behind it is that the marginal cost of external discipline becomes infinite at $\varphi = 0$ when $q < 2$. This property can easily be understood with the following argument. Consider the case where the punishment, γ , is fixed. The cost function then becomes:

$$\Gamma^b(\varphi) = Tc \frac{b^q}{q} + \frac{Td}{4m} \frac{\gamma^m b^2}{(\beta + b^2 \gamma)^2} \text{ with } b^2 \gamma = \varphi$$

and, after substituting b by $(\varphi/\gamma)^{1/2}$:

$$\Gamma^b(\varphi) = \frac{Tc}{q} \left(\frac{\varphi}{\gamma} \right)^{q/2} + \frac{Td}{4m} \frac{\gamma^{m-1} \varphi}{(\beta + \varphi)^2}$$

In other words, if the monitoring cost function is convex with respect to the monitoring intensity, b , whenever $q > 1$, the same property does not necessarily hold with respect to external discipline, φ . We additionally need that $q > 2$. If this condition is not satisfied, the marginal cost, $\Gamma'(\varphi)$, is a decreasing function of external discipline for low values of φ , and it tends towards infinity when

φ goes to 0, thus allowing for the possibility of a corner solution at $\varphi = 0$. What matters here is that the behaviour of the leader depends on the square of the monitoring precision through $b^2\gamma$, -our definition of external discipline- because of the quadratic specification of the probability of fraud detection. Another specification of that probability would have yielded a different necessary condition for the existence of a corner solution at $\varphi = 0$.⁶

For a given value of β , another intuitive interpretation of the preceding theorem is that, when the cost function is concave with respect to total discipline ($q < 2$), the optimal discipline will be the corner solution zero whenever the marginal cost is high in comparison with the marginal utility curve, due to large unit costs of monitoring and punishment and/or high initial income and net aid transfer.

An interesting implication of Theorem 5 is the discontinuity it implies for the way external discipline depends on the parameters of the model. When the quality of governance decreases from some high enough level, the optimal discipline is zero until some threshold is met. From that point, it possibly switches to a strictly positive value. Of course, the same property holds with respect to the other parameters. Thus, a small drop in the quality of the governance of a country, in its initial level of income, or in the volume of aid, may trigger such a jump in external discipline. On the other hand, there may be combinations of parameters such that there is no such discontinuity, the corner solution at $\varphi = 0$ applying for all values of β (so that $\bar{\beta}$ in the preceding theorem is actually tending towards $1/2$, the minimum value set in Section 3.3).

It bears emphasis that the discontinuity does not modify the comparative static results obtained in the preceding case with $q > 2$. For instance, it is still the case that external and internal disciplines are substitutes, but in a weak sense when located at the corner solution, and with a possible discontinuity at some level of the internal discipline.

A natural question that arises is whether Theorem 3 on over- and under-compensation of internal by external discipline still applies. It is evident that no compensation occurs at the corner solution, whereas a huge over-compensation occurs at the discontinuity threshold, $\bar{\beta}$. On the other hand, it can easily be shown that over-compensation always holds for an interior solution. To see this, it is sufficient to notice from (19) and (20) that $\eta < 1$ whenever $q < 2$. Indeed, the proof of Theorem 3 does not rely on the condition $q > 2$ and, by definition of the elasticity η , the condition $\eta < 1$ requires that:

$$\frac{\varphi}{\beta + \varphi} > \frac{(m-1)(q-2)}{2q}$$

which always holds if $q < 2$. Since a low value of q implies little or non convexity of the cost function, the result is according to the aforementioned intuitive

⁶If the value of 2 plays a critical, threshold role for the parameters m and q in the above discussion, it is only because we have chosen to specify the probability of fraud detection as a quadratic function of fraud. Had we chosen $\pi = b^3y^3$ instead of $\pi = b^2y^2$, for example, the expression for external discipline would have been $\varphi = b^3\gamma$ instead of $\varphi = b^2\gamma$, and the threshold value for the parameters m and q would have been 3 instead of 2.

interpretation given to Theorem 3.

The following theorem can therefore be stated:

Theorem 6. *If $m > 2$ and $q < 2$, and if an interior solution prevails ($\beta < \bar{\beta}$), over-compensation of internal by external discipline always occurs.*

The pivotal role of the shape of the monitoring cost function (the cost component that is combined with the detection probability) behind the over-compensation outcome is now plainly in evidence.

It remains to see how the preceding argument is modified in the limit case where $m > 2$ and $q = 2$. Since this implies $mp - 1 = 0$, it can easily be seen on (24) that the marginal cost/marginal utility ratio function is now everywhere increasing as in the case where $m > 2$. Yet, it does not start from zero but from a strictly positive value when $\varphi = 0$ (see Figure 4). If that value is above unity, the optimal solution is the corner solution $\varphi = 0$. In the opposite case, there is an interior solution with the same properties as above for $q < 2$. The condition for a corner solution writes:

$$Bpm\beta^{2(1-p)} \left[w + T \left(1 - \frac{1}{2(\beta)} \right) \right] > 1$$

In line with our expectation, this case is all the more likely as the cost parameters c, d and/or the aid to income ratio T/w are high enough.

6 The particular case: the leader's participation constraint is binding

The donor maximization problem now includes the leader's participation constraint. Bearing in mind (11) which was obtained by substituting the optimal level of fraud, \tilde{y} , into (10), we have that:

$$V(\tilde{y}) = \frac{1}{4(\beta + \varphi)} - g \geq 0 \quad \text{or} \quad \varphi \leq \frac{1}{4g} - \beta$$

It is assumed here that the solution of the general case (15) does not satisfy this constraint. Since that solution does not depend on the cost of managing aid, g , it is sufficient to assume that this cost is sufficiently high for the leader's participation constraint to be binding. The donor has then no choice anymore, and the leader will only agree to manage the aid amount if external discipline is below the threshold $\varphi = 1/4g - \beta$.

The donor's maximization problem is thus trivial as it boils down to minimizing the cost of imposing that level of discipline. This problem was solved above. It comes from (17) that the optimal monitoring is given by:

$$b^{**} = \left[\frac{d}{c} \frac{m-1}{m} 8g^2 \left(\frac{1}{4g} - \beta \right)^m \right]^{\frac{1}{q+2(m-1)}}$$

whereas the optimal punishment is given by :

$$\gamma^{**} = \frac{(\frac{1}{4g} - \beta)}{b^{**2}} = \left[\frac{cmg^{-2}}{8d(m-1)} \right]^{\frac{2}{q+2(m-1)}} \left(\frac{1}{4g} - \beta \right)^{\frac{q-2}{q+2(m-1)}}$$

The comparative-static analysis is rather straightforward and yields the following results. First, when the level of internal discipline, β , increases, the external discipline, φ , is adjusted so as to maintain total discipline, $\beta + \varphi$, constant. We have perfect substitutability between the two types of discipline, instead of under- or over-substituability as before. As a consequence, monitoring decreases as internal discipline improves. However, this holds for punishment only when $q > 2$.

Second, the two disciplining instruments are negatively affected by an increase in their respective cost, and they are clearly gross substitutes.

Third, neither external discipline nor the levels of the disciplining instruments are affected by the size of aid or the poverty of the recipient country. The only parameter other than β that affects φ is the unit cost of handling aid for the leader, g . When g rises, the donor is forced to reduce external discipline in order to keep the leader at his reservation utility. Moreover, it is easy to show that $\delta b^{**}/\delta g < 0$, and it is even more evident that $\delta \gamma^{**}/\delta g < 0$ when $q > 2$.

We are now in a position to summarize the results obtained under the assumption of a binding participation constraint of the leader, allowing for a comparison with the case of a non-binding constraint.

Theorem 7. *When the donor is able to put the leader of the recipient country at his reservation utility, changes in external discipline exactly compensate changes in internal discipline, and this is true regardless of the initial level of internal governance. When $q > 2$, the optimal levels of both monitoring and punishment decrease as internal governance improves. Moreover, they decrease as their respective cost increases, and they are gross substitutes. The size of the aid transfer and the income of the population in the recipient country do not influence external discipline, but the unit cost of handling aid for the leader does. When this cost increases, external discipline is reduced as reflected in a decrease of the levels of both disciplining instruments. When $q \leq 2$, punishment increases with both the internal discipline and the cost of managing aid.*

It remains to specify when the participation constraint is binding. This will be the case if the marginal utility of the external discipline is above its marginal cost, when the external discipline is at the level that makes the leader indifferent between participating or not. Namely:

$$\frac{(4g)^2}{w + T(1 - 2g)} \geq \frac{\eta}{\varphi} B \left[\frac{\varphi^m}{(\beta + \varphi)^2} \right]^p \text{ with } (\beta + \varphi) = 1/4g \text{ and } \eta = p(m - \frac{2\varphi}{\beta + \varphi})$$

Practically, the participation constraint is more likely to be binding as the management cost of aid, g , is high and the level of the external discipline in the unconstrained model tends to be high, i.e. low levels of internal discipline, low

income of the population in the recipient country, and low costs of disciplining instruments (since B is a positive function of c and d).

Notice carefully that, because the above condition involves a reasoning at the margin, it does not apply to the case where $m < 2$ which yields a corner solution at $\varphi = \infty$ and, therefore, makes the leader's participation constraint binding (see Section 4). It is also worth noting that, when $m > 2$, the RHS of the inequality can never take a negative value, so that the possibility of the binding equilibrium depends on the entire set of the model's parameters.⁷

A final remark concerns a simplifying assumption that we have made earlier in order to avoid overburdening our analytical formulas, thus positing that $a = 1$. When a is left free to take on any value, we find that $\delta b/\delta a > 0$, and $\delta \gamma/\delta a > 0$, whether the participation constraint of the leader is binding or not. In words, an increase in the natural variance of the outcome of the aid transfer induces the donor to use his two disciplining instruments more intensively.

7 Remarks and extensions

7.1 Alternative specifications of the objective of the donor

Consider the following additive specification of the objective of the donor, more general than the one used in the analysis:

$$Max_{T,\varphi} U[w + T(1 - \tilde{y})] - V(T + \Gamma) \quad (28)$$

where V is an increasing and convex function of the total cost of aid for the donor and where \tilde{y} is now taken to be a function of φ . The first-order conditions of this problem write:

$$-U'T\tilde{y}' = V'\Gamma' \quad (29)$$

$$U(1 - \tilde{y}) = V' \quad (30)$$

Eliminating V' between these two conditions lead to:

$$-\frac{T\tilde{y}'}{(1 - \tilde{y})} = \Gamma' \quad (31)$$

As Γ' is proportional to T , the solution of that equation has the property that the optimal discipline does not depend on the size of the transfer, T , nor on

⁷Indeed, the only term that can possibly be negative is η/φ , which can be written as:

$$p \left(\frac{m}{\varphi} - \frac{2}{\beta + \varphi} \right)$$

and, after substituting:

$$4pg \left(\frac{m - 2 + 8\beta g}{1 - 4\beta g} \right)$$

For the above expression to be negative, we must have that $m < 2(1 - 4\beta g)$, which is obviously impossible when $m > 2$ since $1 - 4\beta g < 1$. Therefore, the sufficient condition that would make the inequality hold ($\eta/\varphi < 0$) can never be satisfied when $m > 2$.

the initial income of the grassroots, w . But all other properties of the optimal discipline derived in the text hold in this case too. In other words, there is some separability between the optimal discipline and the optimal transfer problem. The optimal discipline problem does not depend on the size of the transfer whereas the reverse does not hold true. The optimal transfer is given by equation (30) for the level of the optimal discipline given by (31).

7.2 Allowing for a corner solution in $\pi(by)$

In Section 4 and 5, we have implicitly assumed that at equilibrium the probability of fraud detection is less than unity. How are our results affected if we allow for the possibility that this probability reaches its maximum value is the question that we need to address in order to make our analysis complete. Getting back to the complete specification of the probability of detection:

$$\pi(by) = \text{Inf}(b^2 y^2 / a^2, 1)$$

we now prove that the corner solution $\pi(by) = 1$ will never be optimal for the donor.

First, let us characterize completely the behavior of the leader, including the corner solution. Given the leader's objective as stated under (1), there are two regimes for the leader, depending on which part of the probability of detection is relevant:

- Limit regime (0): $\pi(by) = 1$. Then, $y^* = y_0 = 1/(2\beta)$ and $V^* = V_0 = 1/(4\beta) - \gamma - g$
- Normal regime (1): $\pi(by) = b^2 y^2 / a^2$. Then, $y^* = y_1 = 1/2(\beta + \varphi)$ and $V^* = V_1 = 1/4(\beta + \varphi) - g$

The optimal regime is the one that maximizes V^* . It is regime 1 if

$$V_0 = 1/(4\beta) - \gamma - g \leq V_1 = 1/4(\beta + \varphi) - g$$

After eliminating γ through $\gamma = \varphi a^2 / b^2$, this is equivalent to:

$$b^2 \leq 4a^2 \beta (\beta + \varphi) \tag{32}$$

We can now prove the following theorem:

Theorem 8. *It is never in the interest of the donor to allow the leader to settle in regime 0.*

The proof (provided in Appendix C) proceeds in two steps since we have to show that the donor's optimal choice is regime 1 whether the leader's participation constraint is binding (the particular case) or not binding (the general case).

Our task does not end here, however. We must indeed ensure that, in the general case, the donor maximizes his objective under the constraint that the leader is maintained in regime 1. Formally, this constraint must be taken into

account when defining the cost of implementing some predefined level of external discipline in (16). This problem now writes:

$$\Gamma(\varphi) = \min_b Tcb^q/q + \frac{Td}{4m} \frac{b^{2(1-m)}}{(\beta + \varphi)^2} \varphi^m \quad \text{for given } \varphi$$

$$\text{and subject to : } b^2 \leq 4\beta(\beta + \varphi)$$

The latter constraint is binding when the derivative of the cost at $b^2 = 4\beta(\beta + \varphi)$ is negative. In that case, the donor would like to increase b but would violate the constraint that maintains the leader in regime 1. Thus, the constraint is binding whenever:

$$Tc[4\beta(\beta + \varphi)]^{(q-1)/2} \leq \frac{Td}{2c} \frac{m-1}{m} \frac{[4\beta(\beta + \varphi)]^{(1-m)-1/2}}{(\beta + \varphi)^2} \varphi^m$$

This may be rewritten after some transformation as:

$$\Delta(\varphi) = \varphi^m (\beta + \varphi)^{-m-1-q/2} \geq 2^{q+2m-1} \beta^{m-1+q/2} \frac{m}{m-1} \frac{c}{d} = \psi$$

It can be seen that the function $\Delta(\varphi)$ has a inverted U-shape with a maximum at $\varphi^* = m\beta/(1 + q/2)$. In other words, the constraint to maintain the leader in regime 1 is binding for values of the internal discipline that lie within some intermediate range. However, there is a case where the preceding inequality is violated for all values of φ . It is when the maximum of $\Delta(\varphi)$ at φ^* is below ψ . It turns out that this condition is equivalent to:

$$\beta^{m+q} \geq \left(\frac{d}{c}\right) m^m \left(\frac{m-1}{m}\right) \frac{(1 + q/2)^{1+q/2}}{(m+1 + q/2)^{(m+1+q/2)} 2^{q+2(m-1)}} = \beta^*(m, q, d/c)$$

This result is stated in the following theorem:

Theorem 9. *(normal regime is optimal) There exists a threshold of the internal discipline above which the constraint of maintaining the leader in the normal regime is never binding and the solution of the general case applies.*

The intuition behind Theorem 10 is rather obvious. For low levels of internal discipline, the donor would like to impose a high level of external discipline, so high that the leader in the recipient country would switch to regime 0. As this would not be a satisfactory outcome for the donor, he imposes the discipline that makes the leader indifferent between the two regimes. Another way to look at the condition is through the role of the cost parameters. Since β^* varies positively with the ratio d/c , the implication is that the larger the unit cost of monitoring relative to that of punishment the more likely regime 1 prevails in an unconstrained manner. And vice-versa if the ratio d/c is high. This is again according to intuition: when monitoring is costly, the donor is not induced to set monitoring precision at such a high level that the probability of fraud detection will reach unity.

In discussing the general case as we did in Subsection 3.4.2, we implicitly assumed that the above condition is always satisfied. Absent this assumption, the problem becomes obviously quite intricate since the cost curve $\Gamma()$ would have different expressions depending on the value of φ . As is evident from the second point in the aforementioned interpretation, the analytical argument followed to handle the general case relies on the most intuitive idea that monitoring costs are significant enough to discourage the donor from choosing perfect detection of the leader's fraud.

7.3 Why the case of an altruistic/paternalistic leader has been ruled out

Instead of the original objective function (1), let us consider the case of an altruistic or paternalistic leader who attaches a weight α to his own income and a weight $(1 - \alpha)$ to the income accruing to his constituency. This specification is reminiscent of the so-called "paternalistic altruism" whereby Azam and Laffont (2003) describe the behavior of local elites in poor countries. In effect, the weight $(1 - \alpha)$ needs not be interpreted strictly as a coefficient of altruism, but may be alternatively viewed as the bargaining power wielded by the leader's constituency (people are able to compel the leader to take their interests into account). Whichever the interpretation, the leader's utility function is now written as follows:

$$V(y) = \alpha y + (1 - \alpha)(1 - y) - \alpha\gamma\pi(by) - g = y(2\alpha - 1) + (1 - \alpha) - \alpha\gamma\pi(by) - g$$

Equivalently, we may write a function adjusted from Azam and Laffont (2000):

$$V(y) = y + \theta(1 - y) - \gamma\pi(by) - g$$

We may then derive the leader's optimum fraud, assuming that the punishment is strong enough and the monitoring precise enough, so that dV/dy cannot be positive when $y = 1$ (and bearing in mind that α must exceed $1/2$ for the problem to be non-trivial in the case of the first specification). With the second specification, the equivalent of the optimal behavior of the leader (7) now is: $\tilde{y} = (1 - \theta)/2\varphi$. It is still the case that the optimal fraud decreases with the altruistic coefficient - or internal discipline- θ and with the external discipline φ .

There is yet a particular problem that arises when an altruistic function is used to depict the leader's behavior. The problem is that we cannot be certain that the indirect utility of the leader decreases when the domestic governance improves (the altruism coefficient increases). Sticking to the Azam and Laffont's specification, we find that the optimal level of the leader's utility is $V^I = V(\tilde{y}) = \frac{1}{2\varphi} \left(1 - \frac{(1-\theta)^2}{2}\right) - g$, from which it immediately follows that $\frac{dV^I}{d\theta} = \frac{1}{2} \left(\frac{1-\theta}{\varphi}\right) > 0$. In other words, the leader's utility always increases as the weight given to the citizenry is raised while the aid delivery parameters are kept constant.

This is not a peculiarity of simple altruistic functions such as those mentioned above. For example, let us posit a quite general utility function of the type:

$V(x) = u(x, e) + \theta U(z, e)$, where x is the wage the leader receives from the donor, z is the amount of aid money, and e is the choice variable of the leader and measures the quality of the leader's input into the project funded by the donor. According to one interpretation, e is the level of theft of project funds, so that lower values of e are associated with higher levels of theft. The function $u(-)$ represents the 'direct utility' of the leader, and $U(-)$ the welfare of the community. It can then be shown that, under reasonable assumptions, given an optimal choice of e , the leader's utility increases in θ (see Wahhaj, 2008).

A consequence of the above result is that, in order to maintain the leader at his reservation utility, the donor will respond to an increase in θ by paradoxically increasing the external discipline and therefore the monitoring precision and/or the punishment level, and vice-versa if θ has fallen. When we compute the comparative-static effects from the donor's problem, we thus find that at least one of the effects, $\delta b/\delta\theta$ or $\delta\gamma/\delta\theta$, remains indeterminate while the other has the unexpected positive sign.⁸

Clearly, altruism as reflected in a positive weight given to the utility of the grassroot population is not a convenient manner to represent domestic governance. We can nevertheless interpret our own original specification (1) as a kind of genuinely paternalistic altruism, in the sense that the leader has his own conception of the way he may harm the community by embezzling funds. The coefficient β then scales up or down a self-inflicted cost incurred by the leader when he deprives the community of a part of the aid fund and which is a convex function of that amount.

7.4 The case of a probability function with a threshold

We assume here that the fraud detection probability function has a threshold ($h > 0$) below which fraud cannot be detected. This can be represented by a simple extension of the original specification of the detection probability (4):

$$\pi(by) = 0 \text{ for } y \leq h/b ; \pi(by) = \frac{(by - h)^2}{a^2} \text{ for } h/b \leq y \leq 1/b$$

The model now becomes more complex owing to the possibility of a corner solution for the leader. This happens when the leader chooses the level of embezzlement in such a way as to avoid the risk of detection altogether. Formally, the solution of the leader's programme cannot lie inside the interval $[0, h/b]$, yet it can be at the corner point $\hat{y} = h/b$. Indeed, the first derivative of the leader's

⁸Note, incidentally, that the same oddity characterizes Azam-Laffont's model in which the optimal amount of aid granted (which is a variable) is shown to depend linearly on the consumption of the poor as decided by the leader (the government). The authors show that, when θ increases, the coefficient of the variable component of the aid contract decreases, pointing to a relaxation of the donor's discipline, the expected effect. When we complete the exercise and compute the effect of the same parametric change on the contract's fixed component, we nevertheless find that the value of this component may decrease under feasible conditions (proof available from the authors of the present paper), implying a counter-intuitive tightening of the donor's discipline.

utility function at that point when is $dV/dy = 1 - 2\beta(h/b)$. It follows that the condition for the corner solution is:

$$\frac{h}{b} > \frac{1}{2\beta} \quad (33)$$

The interpretation of the above is straightforward: the leader chooses the zero-detection level of fraud if domestic governance is sufficiently strong relative to that level. For a given degree of monitoring precision, indeed, a large β means that it is costly for the leader to embezzle too much aid money.

When the condition (33) is violated and the interior solution prevails, we have:

$$\tilde{y} = \frac{1}{2[\beta + \varphi(1 - \frac{h}{b})]} \quad (34)$$

>From the comparison between (7) and (34), it comes that $\tilde{y} > \tilde{y}^*$: as expected, for given values of the disciplining instruments, the leader embezzles more when there is a zero-detection zone in the monitoring process.

The leader will be at the corner or at the interior solution depending on the outcome of the donor's optimization: the donor will induce the leader to be at the corner if his own indirect utility is higher than it would be with the interior solution. As it is evident from (33), the donor uses b but not γ towards such a purpose. In the case of the corner solution, b^* is set at a level low enough to cause h/b^* to exceed $1/2\beta$, yet at the same time, b should not be too small since \tilde{y} varies inversely with b at the corner. It thus comes that $b^* = 2\beta h$. As for γ , its value is indeterminate, a direct consequence of the fact that the cost $D(\gamma)$ is incurred only in the event of fraud detection (see Appendix D for the full proof).⁹

When the interior solution prevails, so that the equilibrium fraud level is given by (34), the donor's optimization programme may not be solved sequentially, even when the leader is put at his reservation utility. Like in the case where $h = 0$, some comparative-static effects are impossible to sign unambiguously, and there exists the possibility that b and γ are used as substitutes by the donor.

8 Conclusion

With the help of a parsimonious principal-agent model, we have studied the behaviour of a donor who is willing and able to discipline the local elite of a recipient country. Since our interest mainly lies in understanding the interaction between the internal and external disciplines, we have specified the objective function of this elite in such a way that the two types of discipline not only have a bearing on its income but also lend themselves to an aggregating operation. This has enabled us to analyse how total discipline is affected by parametric changes

⁹It can also be shown (see Appendix E) that $\delta b^*/\delta h > 0$: the donor responds to an increase in the tolerance margin by enhancing monitoring precision. Moreover, $\delta b^*/\delta \beta > 0$.

and, in particular, by a variation in domestic or internal discipline. As expected, external discipline acts as a substitute for internal discipline and, therefore, when domestic discipline is increased in the recipient country the donor responds by reducing the level of external discipline (along both the monitoring and the punishment dimensions). Yet, since the outcome of governance, measured as the proportion of aid effectively reaching the poor (or the inverse of local elite capture), depends on total discipline, the central question is whether the improvement in internal discipline also results in an increase in total discipline so that the poor can obtain a higher share of the aid money.

In the table below, we have summarized the main properties of the optimal disciplining and aid delivery instruments as a function of some of the parameters of this simple framework.

When the elite's participation constraint is binding, we reach the rather unexpected conclusion that internal and external disciplines exactly balance out with the consequence that total discipline and the share of the poor remain constant. When the elite is able to retain a surplus from the aid transfer, our surprise actually increases. It now becomes possible that an improvement in domestic discipline is over-compensated by the donor so that total discipline is paradoxically reduced and elite capture increases. Whether this happens or not depends on the initial level of internal discipline and on the shapes of the cost functions, that is, on the technologies of monitoring and punishment available to the donor. Moreover, the relationship between internal discipline and total discipline or the level of elite capture is not necessarily monotonous: if initially there is over-substitution of internal by external discipline and elite capture is an increasing function of internal discipline, both properties are likely to revert at some stage as internal discipline improves. The policy implication is important: if one wishes to avoid the paradoxical effect according to which the population of the recipient country is 'punished' by the donor for achieving a better domestic discipline, innovations must ensure that monitoring and punishment technologies are not too convex in their costs.

On the other hand, if the cost function for punishment exhibits small convexity, the optimal discipline imposed by the donor is such that the punishment is infinitely large and the monitoring infinitely small. Yet, in that case, it is unlikely the elite in the recipient country will accept such conditions. In order to help the poor population in that country, the donor cannot set the external discipline at a level that exceeds the participation constraint of the elite. The other extreme solution in which the donor optimally chooses to abstain from imposing any discipline on the recipient country is another possibility. It is more likely to arise if the cost function for monitoring exhibits small convexity and the unit costs of monitoring and punishment are sufficiently high, and/or if the initial level of living in the recipient country and the size of the aid transfer are also sufficiently high.

As attested by the last finding, the model has the original feature of allowing the study of the effects of aid availability in addition to those of the initial income level. This is done in a framework where the utility of the donor is concave in the average income accruing to the recipient population, itself the sum of its stand-

alone income and the amount of aid money per capita. With respect to the latter, the most interesting result is the following: when the elite's participation constraint is not binding, the optimal external discipline chosen by the donor decreases with the size of the aid transfer. When this constraint is binding, however, external discipline is unaffected by the amount of aid money. In other words, a greater aid supply induces the donor to relax his discipline but only when he is unable to put the local elite at its reservation utility. The effect of the initial level of income in the recent country is analogous to that of the transfer amount: a higher income induces the donor to relax his discipline but only when the elite's participation constraint is not binding.

The major implication of the whole endeavor is, therefore, that when governance is considered to be partly endogenous to the donor's effort, no general prediction can be made about the effect of aid on the donor's objective (poverty reduction in this paper). We need to know more about initial levels of domestic governance, the aggregate amount of aid available, and the characteristics of the disciplining technology to be able to infer more precise testable propositions. Absent such information, empirical results are likely to be misleading or hard to interpret.

Table 1: Properties of optimal aid delivery instruments: a summary table

m and q	g 'small'	g 'high'
$m \leq 2$	$\varphi = 1/4g - \beta$	
$m > 2; q > 2$	$\varphi < 1/4g - \beta; \frac{\partial \varphi}{\partial \beta} < -1$ $\frac{\partial \varphi}{\partial c}, \frac{\partial \varphi}{\partial d}, \frac{\partial \varphi}{\partial w}, \frac{\partial \varphi}{\partial T} < 0$ $\frac{\partial b}{\partial \varphi}, \frac{\partial \gamma}{\partial \varphi} > 0; \frac{\partial b}{\partial c}, \frac{\partial \gamma}{\partial d} < 0$	$\varphi = 1/4g - \beta; \frac{\partial \varphi}{\partial \beta} = -1$ $\frac{\partial b}{\partial \beta}, \frac{\partial \gamma}{\partial \beta} < 0$
$m > 2; q \leq 2$		
c, d or w, T low	$\varphi < 1/4g - \beta; \frac{\partial \varphi}{\partial \beta} < -1$ $\frac{\partial \varphi}{\partial c}, \frac{\partial \varphi}{\partial d}, \frac{\partial \varphi}{\partial w}, \frac{\partial \varphi}{\partial T} < 0$ $\frac{\partial b}{\partial \varphi}, \frac{\partial \gamma}{\partial \varphi} > 0; \frac{\partial b}{\partial c}, \frac{\partial \gamma}{\partial d} < 0$	$\varphi = 1/4g - \beta; \frac{\partial \varphi}{\partial \beta} = -1$ $\frac{\partial b}{\partial \beta} < 0, \frac{\partial \gamma}{\partial \beta} > 0$
c, d or w, T high	$\varphi = 0$	

Figures

Figure 1: Equilibrium of marginal utility and marginal cost of external discipline when $q > 2$ and $m > 2$

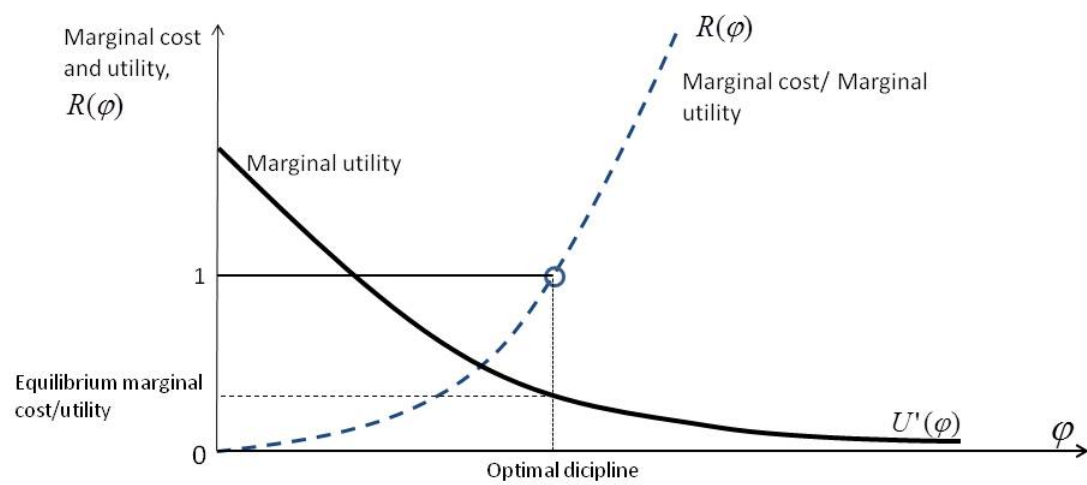


Figure 2: Equilibrium of marginal utility and marginal cost of external discipline when $m > 2$ and $q \leq 2$: case where the optimal discipline is $\varphi = 0$

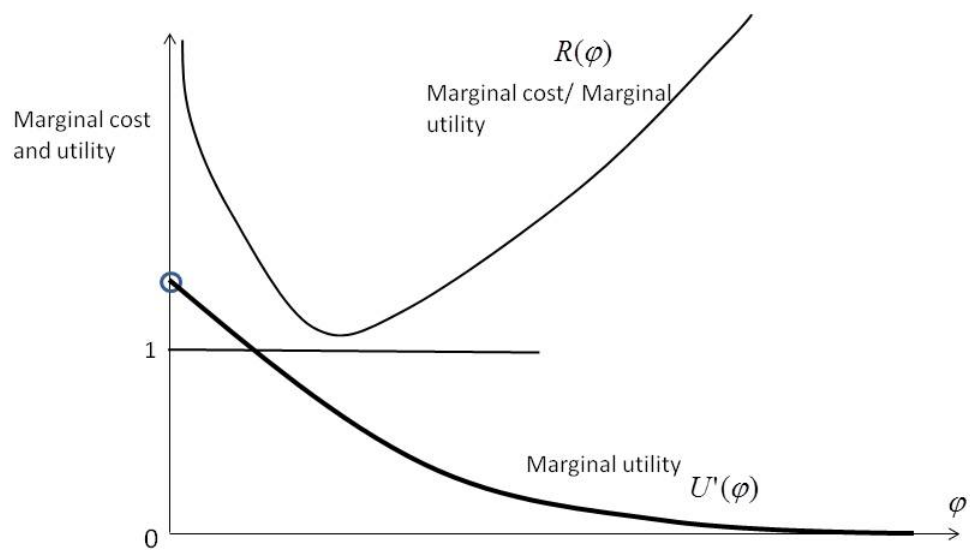


Figure 3: Equilibrium of marginal utility and marginal cost of external discipline when $m > 2$ and $q \leq 2$: case where the optimal discipline is interior solution φ^0

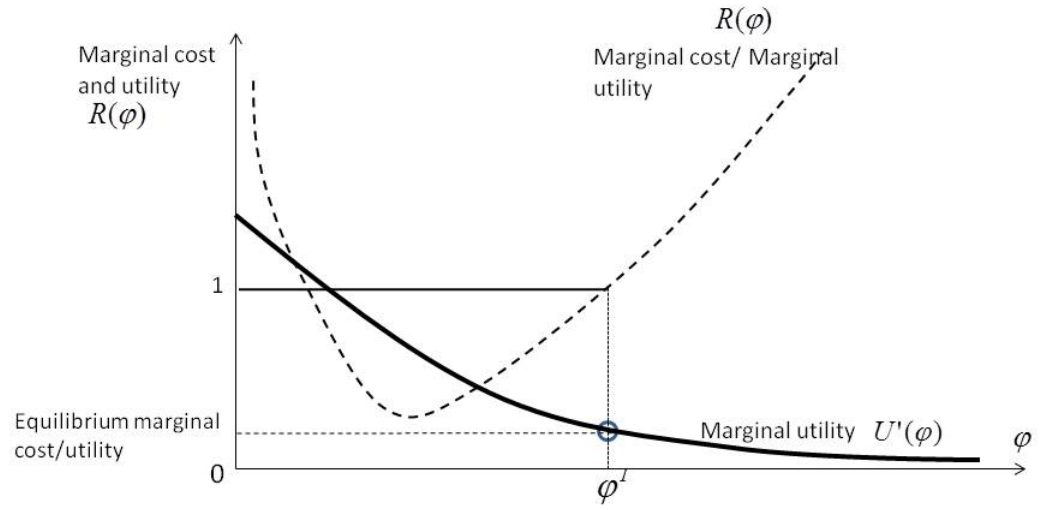
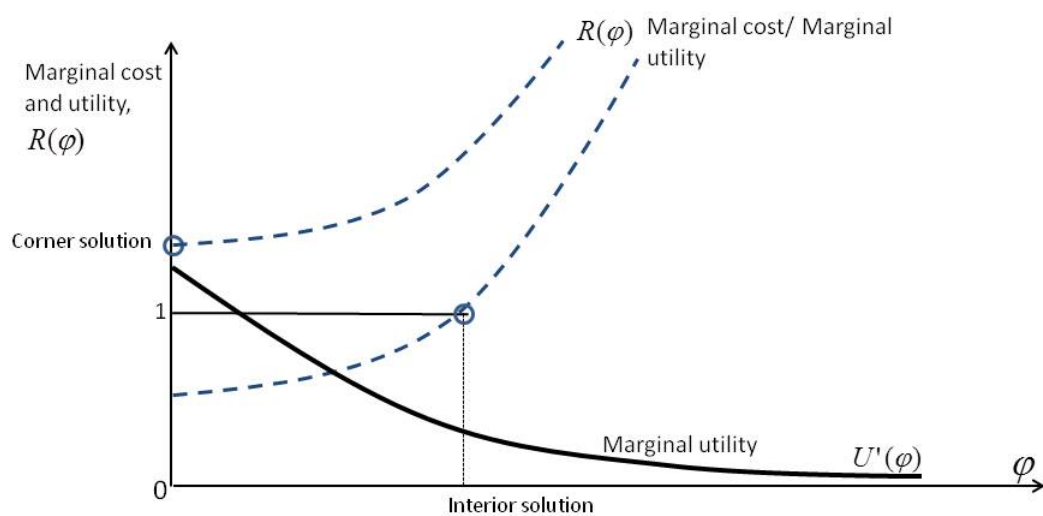


Figure 4: Interior and corner equilibria when $m > 2$ and $q = 2$



Appendix A: Notations

The basic notations used in the paper are thus:

- T = the size of the aid program;
- y = the share of aid appropriated by the leader or the elite of the recipient country (that is, the extent of 'fraud'): $y \in [0, 1]$
- β = the internal governance parameter of the recipient country, or the cost inflicted by the national community on a leader who behaves fraudulently: $\beta \in [0, 1]$;
- b = the degree of precision achieved in the monitoring of the country leader's behavior ($\in 0, \infty$).
- a = the quality of the signal about the effect of the aid program
- $\pi(by)$ = the probability of fraud detection;
- h = the threshold below which fraud remains undetected;
- γ = the amount of the penalty if the fraud is detected;
- g = the cost of handling one unit of aid for the leader;
- V° = the reservation utility of the leader;
- $C(b)$ = the cost of monitoring;
- $D(\gamma)$ = the cost of imposing the penalty level γ .

Appendix B: Donor's behavior when the leader's participation constraint is not binding

B1: Proof of Theorem 1

We need first to show that when $m \geq 2$ and $q > 2$ then, the function $R(\varphi)$ is increasing with φ from 0 to ∞ . Clearly the first and third bracketed terms in (24) are increasing functions of φ . The logarithmic derivative of the middle term is given by:

$$(mp - 1)\frac{1}{\varphi} - (2p - 1)\frac{1}{\beta + \varphi} = \frac{(mp - 1)\beta + (m - 2)p\varphi}{\varphi(\beta + \varphi)}$$

which is strictly positive whenever $m \geq 2$ and $q > 2$. Under the same conditions, it is the case that $R(0) = 0$ and $R(\infty) = \infty$. The equilibrium condition $R(\varphi) = 1$ thus has a unique strictly positive solution.

To prove the second part of Theorem 1, we log differentiate the ratio function $R(\varphi)$ with respect to β and we show that its derivative is positive. As $R(\varphi)$ is increasing with φ , reestablishing equilibrium after an increase in β requires reducing the external discipline.

Formally:

$$\frac{1}{R(\varphi)} \frac{\partial R(\varphi)}{\partial \beta} = \frac{1}{\Gamma'(\varphi)} \frac{\partial \Gamma'(\varphi)}{\partial \beta} - \frac{1}{U'(\varphi)} \frac{\partial U'(\varphi)}{\partial \beta}$$

Differentiating the RHS leads to:

$$\frac{1}{\Gamma'(\varphi)} \frac{\partial \Gamma'(\varphi)}{\partial \beta} = \frac{m}{(m-2)\varphi + m\beta} - (2p-1) \frac{1}{\beta + \varphi}; \quad \frac{1}{U'(\varphi)} \frac{\partial U'(\varphi)}{\partial \beta} = -\frac{2}{\beta + \varphi} - U'(\varphi)$$

At equilibrium, we know that $\Gamma'(\varphi) = U'(\varphi)$ so that:

$$\text{sign} \left\{ \frac{\partial R(\varphi)}{\partial \beta} \right\} = \text{sign} \left\{ \frac{m}{(m-2)\varphi + m\beta} - (2p-3) \frac{1}{\beta + \varphi} + U'(\varphi) \right\}$$

As $(2p-3)$ is necessarily negative (since $p < 1$), it follows that $\frac{\partial R(\varphi)}{\partial \beta}$ is positive. QED

B2: Proof of Theorem 2.

To derive condition (27), differentiate the marginal cost (20) with respect to φ , keeping $(\beta + \varphi)$ constant, and denote Δ_φ the corresponding operator. The intuitive proof in the text is not fully correct because, in using the elasticity of the cost function, it ignores the fact that this elasticity must now be evaluated at constant $(\beta + \varphi)$. More rigorously, it comes that:

$$\frac{\Delta_\varphi(\Gamma')}{\Gamma'} = \frac{\Delta_\varphi(\eta)}{\eta} - \frac{1}{\varphi} + \frac{\Delta_\varphi(\Gamma)}{\Gamma}$$

But the last term on the RHS can also be written as:

$$\frac{\Delta_\varphi(\Gamma)}{\Gamma} = \frac{\Gamma'}{\Gamma} + \frac{2p}{\beta + \varphi} = \frac{\eta}{\varphi} - \Delta_\varphi(\eta)$$

Hence the final result:

$$\frac{\Delta_\varphi(\Gamma')}{\Gamma'} = \left[\frac{1}{\varphi} - \frac{\Delta_\varphi(\eta)}{\eta} \right] (\eta - 1)$$

As the cost elasticity η depends negatively on φ for given $(\beta + \varphi)$, the term in square bracket is positive and Theorem 2 follows. QED.

B4: Proof of Theorem 3

Assume an initial situation such that

$$\frac{\varphi}{\beta + \varphi} > \frac{(m-1)(q-2)}{2q} \tag{35}$$

and an increase in β . First, it is plain to see that the LHS of that inequality decreases with β . Indeed, the first derivative writes:

$$\frac{d\left(\frac{\varphi}{\beta + \varphi}\right)}{d\beta} = \frac{\beta \frac{d\varphi}{d\beta} - \varphi}{(\beta + \varphi)^2}$$

But as $d\varphi/d\beta$ is negative from Theorem 2, it follows that $\varphi/(\beta + \varphi)$ decreases with β . If, initially, there is over-substitution of internal by external discipline, the situation is bound to revert as β increases and (35) is less and less likely

to hold. If so, the optimized fraud increases with β when β is small and most of the overall discipline is external. At some stage, however, the relationship is turned upside down and the optimized fraud decreases when β increases.

B5: Proof of Theorem 4

Given in the text.

B7: Proof of Corollary 1

Differentiate (17) logarithmically with respect to φ and β . It comes :

$$\text{sign} \frac{\partial b^*}{\partial \beta} = \text{sign} \left[\left(\frac{m}{\varphi} - \frac{2}{\beta + \varphi} \right) \cdot \frac{\partial \varphi}{\partial \beta} \right] - \frac{2}{\beta + \varphi}$$

This expression is negative as long as φ reacts negatively to an increase in β , which is the case according to Theorem 1.

Things are less easy for $\partial \gamma^* / \partial \beta$. First, the optimal punishment is defined by:

$$\gamma^* = \varphi / b^{*2}$$

Replacing by (17), it comes that the optimal punishment is given by:

$$\gamma^* = \varphi \left[\frac{d}{c} \frac{m-1}{2m} \frac{\varphi^m}{(\beta + \varphi)^2} \right]^{\frac{-2}{q+2(m-1)}}$$

Differentiating logarithmically with respect to φ and β leads to:

$$\text{sign} \left(\frac{\partial \gamma^*}{\partial \beta} \right) = \text{sign} \left[\frac{\partial \varphi}{\partial \beta} - \frac{\varphi / (\beta + \varphi)}{\varphi / (\beta + \varphi) + (q-2)/4} \right] \quad (36)$$

After some manipulation, differentiating the equilibrium condition $R(\varphi) = 1$ with respect to φ and β yields:

$$\frac{\partial \varphi}{\partial \beta} = - \frac{\varphi / (\beta + \varphi)}{\varphi / (\beta + \varphi) + N/M}$$

where:

$$M = \frac{1}{(\beta + \varphi) - 1} + \frac{4(m-1) [m(\beta + \varphi) - \varphi] + 2q\varphi}{[q + 2(m-1)] [m(\beta + \varphi) - 2\varphi]},$$

$$N = \frac{m(m-1)(q-2)(\beta + \varphi) - 2qm\varphi}{[q + 2(m-1)] [m(\beta + \varphi) - 2\varphi]}$$

It is then easily proven that $N/M \leq (q-2)/4$, so that the sign in (36) is negative. QED

B8: Proof of Corollary 2

In the text.

B9: Proof of Theorem 5

As $mp - 1 < 0$ when $q < 2$, $R(\varphi)$ is U-shaped, going from infinity to infinity when φ varies from 0 to ∞ . To see this, note that the middle bracketed term in (24) has this U-shape, going through a minimum for $\varphi = -(mp-1)\beta/(m-2)p$, whereas the two other terms are increasing and positive functions of φ . It

follows that $R(\varphi)$ goes through a minimum for some strictly positive value φ_m . If $R(\varphi_m) > 1$, the optimal discipline is the corner solution $\varphi = 0$. If $R(\varphi_m) \leq 1$, there exist two solutions to the equation $R(\varphi) = 1$ but only the largest, for which $R'(\varphi) \geq 0$, can be a local optimum of the donor's objective. Let φ^I be that solution and W^I the corresponding value of the donor's objective. The optimal discipline is then either $\varphi = 0$ or φ^I depending on whether W^I is below or above the objective of the donor when he/she exerts no external discipline, $W^0 = \text{Log}[w + T(1 - 1/2\beta)]$.

We now want to show that, for some values of the cost parameters c, d, w and T , there exists a threshold $\bar{\beta}$ such that the corner solution $\varphi = 0$ is optimal when β is above that threshold. To do so, we prove that: a) $R(\varphi)$ increases monotonically with β , and b) there are two values of β such that the optimal external discipline is 0 for the highest value and strictly positive for the smallest value.

As far as a) is concerned, it is sufficient to notice that $q < 2$ and $m \geq 2$ imply that $2p - 1$ is negative. Indeed,

$$2p - 1 = \frac{q - 2(m - 1)}{q + 2(m - 1)}$$

but $m \geq 2$ implies that $q < 2 \leq 2(m - 1)$. It follows that, when $m \geq 2$ and $q < 2$, $R(\varphi)$ in (24) increases with β . In Figure 3, therefore, the curve $R(\varphi)$ shifts entirely upwards as β increases.

To prove b) above, consider an arbitrary value β_0 of β and $\beta = \infty$. When β tends toward infinity, $R(\varphi)$ is increasingly large and therefore everywhere above unity so that the optimal discipline is undoubtedly 0 in that case. Consider then the case $\beta = \beta_0$ and assume that the cost parameters (c, d) are low enough so that $R(\varphi_m) < 1$. Then evaluate the difference between the donor's objective at the corresponding local optimum φ^I and at the corner solution $\varphi = 0$. It is given by:

$$D = \text{Log} \left[\frac{w + T(1 - \frac{1}{2(\beta_0 + \varphi^I)})}{w + T(1 - \frac{1}{2\beta_0})} \right] - \Gamma(\varphi^I)$$

Note that the first term on the RHS is strictly positive. Then rescale the cost parameters (c, d) by a scalar λ without changing the external discipline so that $\Gamma(\varphi^I)$ in the preceding expression is itself multiplied by λ - see (18) above.

$$D = \text{Log} \left[\frac{w + T(1 - \frac{1}{2(\beta_0 + \varphi^I)})}{w + T(1 - \frac{1}{2\beta_0})} \right] - \lambda \Gamma(\varphi^I)$$

Allowing λ to become increasingly small will necessarily make the difference D positive at some stage. Now allow the external local optimum φ^I to adjust to the rescaling of the cost parameters by λ . Since this necessarily raises the value of the donor's objective, the difference D remains positive and the new local optimum is a global optimum. We have thus shown that for any arbitrary value of β there are parameter values (c, d, w, T) such that the optimal external

discipline is given by the (strictly positive) interior solution rather than the corner solution at 0. Hence, for these parameters values, there exists a threshold $\bar{\beta}$ with the property stated in Theorem 5. Note, however, that there are also parameter values (c, d, w, T) such that the global optimum is necessarily the 0 corner solution. In this case, the threshold $\bar{\beta}$ is simply the minimum possible value of β which has been seen to be $1/2$ (see Section 3.3). QED

Appendix C: Donor's behavior when a corner solution in $\pi(by)$ is considered

We examine the two possible cases (leader's participation constraint binding or not), successively. First consider the general case. The donor's maximization problem when the leader is in regime 0 writes:

$$\text{Max } \text{Log}(w + T(1 - \frac{1}{2\beta})) - Tcb^q/q - Td\gamma^m \text{ins}/m \text{ with } b^2 \geq 4\beta(\beta + \varphi)$$

The optimum is obtained by allowing γ , and therefore φ , to tend towards zero and by setting the monitoring to the minimum consistent with the leader remaining in regime 0, i.e. $b = 2\beta$.

Clearly, such a policy with $\gamma = 0^+$ and $b = 2\beta$ cannot be optimal for the donor since it is dominated by the $\varphi = \gamma = b = 0$ policy which sets the leader in regime 1. As seen earlier, the latter is optimal if $q \leq 2$ and the unit costs of aid delivery instruments (c,d) and/or the income of the recipient country and the size of the transfer (w, T) are large enough. It is itself dominated by a non-zero external discipline if these conditions are not satisfied.

Consider now the case where the participation constraint of the leader is binding. If the leader is in regime 0, the participation constraint writes:

$$V_0 = 1/(4\beta) - \gamma - g = 0$$

which sets a value for γ . The donor must then set the monitoring instrument and the internal discipline at a level b_0 and φ_0 consistent with regime 0, that is the opposite of (32). This leads to:

$$b_0^2 = 4\beta(\beta + \varphi_0) \text{ or } b_0^2 = \frac{\beta}{g} \text{ and } \varphi_0 = (\frac{1}{4g} - \beta)$$

Starting from this situation, imagine however that the donor decides to set the monitoring at a slightly lower level and the punishment at a slightly higher level so as to maintain the external discipline constant. This would not change its costs but would then force the leader to switch from regime 0 to regime 1, with a discontinuity in the fraud from $1/2\beta$ to $1/2(\beta + \varphi_0)$. The leader would be indifferent between these two situations and the donor would clearly be better off with the same costs and a higher level of utility. QED

Appendix D: The corner solution when the fraud detection function has a threshold

We differentiate (13) with respect to b and γ , bearing in mind that $\tilde{y} = h/b$ in the case the corner solution obtains. We immediately see that the second first-order condition is always equal to zero (all the terms actually vanish), regardless of the value taken on by γ , which is therefore indeterminate. As for the first equilibrium condition, since not only $\pi(by)$ but also $d\pi/dy$ are zero at the corner point, it takes the simple following form:

$$\frac{h}{b^2} - C'(b)\frac{G}{T} + \mu\frac{h}{b^2}\left(2\beta\frac{h}{b} - 1\right)\frac{G}{T} \leq 0,$$

where $G = w + T(1 - \tilde{y}) = w + T(1 - h/b)$. At the corner solution, we have that $h/b > 1/2\beta$, implying that $(2\beta h/b) > 1$. In the above condition, there is thus two positive terms and one negative term, so that the optimal value of b is given by:

$$C'(b)\frac{G}{T} = \frac{h}{b^2}\left[1 + \mu\frac{G}{T}\left(2\beta\frac{h}{b} - 1\right)\right]$$

Defining $\phi = \frac{h}{b^2} - C'(b)\frac{G}{T} + \mu\frac{h}{b^2}\left(2\beta\frac{h}{b} - 1\right)\frac{G}{T}$, we can sign the comparative-static effects $\delta b^*/\delta h$ and $\delta b^*/\delta \beta$.

First note that $\phi_b < 0$, by virtue of the second-order condition. We also have that

$$\phi_h = \frac{1}{b^2} + C'(b)\frac{1}{b} + \frac{\mu}{b^2}\frac{G}{T}\left(2\beta\frac{h}{b} - 1\right) + \mu\frac{h}{b^3}\left(2\beta\frac{G}{T} - 1\right)$$

This expression is unambiguously positive because $2\beta h/b$ is greater than one because of (33), and $2\beta G/T$ is a fortiori greater than one because G/T must be higher than $\tilde{y} = h/b$. As a consequence, $\delta b^*/\delta h = -\phi_h/\phi_b > 0$. On the other hand, $\delta b^*/\delta \beta = -\phi_\beta/\phi_b > 0$, because

$$\phi_\beta = 2\mu\frac{h^2}{b^3}\frac{G}{T} > 0$$

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